THE MINERALOGY OF SOME SOILS AND SHALES FROM SALINE COUNTY, KANSAS

by

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INTRODUCTION

The development of a soil from bedrock is the result of various physical and chemical changes in that bedrock material. There are many factors which affect the development of a soil and determine the character of the mature soil. One of the most important of the soil forming processes is the climate. Of less importance are such factors as vegetative covering, topography, and parent material.

If the soils in a given region are investigated, then the factor of climate will be fairly uniform in the development of all the soils. By careful selection of samples, it should be possible to find soils developed on the same general type of topography and with the same vegetation. This leaves the parent material as the variable factor, and investigation of the various types of soils formed in such a restricted area should show the effects of parent material on soil types.

Another soil forming factor is time. Under any set of conditions, the longer the time interval, the more intense the effect of all factors. In the case of a group of soils formed within a limited area it is reasonable to assume that all of the soils are of about the same age.

Most soil scientists believe that the effect of parent material on a soil is very slight when the soil is completely mature. The nature of the parent material, however, will affect the length of time required to produce a mature soil. Therefore, within a limited area where there are several soils of the same general age but developed on various types of parent materials it would be expected that some of the soils will be more mature than others.

This investigation was made with several objectives in mind. One of the objectives was to determine the mineral composition of the various parent materials so that the parent material could be distinguished, if possible. Secondly, an attempt was made to show changes in the mineral composition between parent material and the various soil horizons of the soil developed on that parent material. Lastly, a comparison of similar soil horizons of different soils was made to determine the degree of similarity of the mineral compositions of the different soils.

The area of investigation was Saline County, Kansas. Saline County is located in the north central part of Kansas. It is in the fourth row of counties from the northern boundary of Kansas and in the seventh row from the eastern boundary.

Mr. Paul L. Brown, of the Agronomy Department of Kansas State College, Manhattan, assisted in a soils mapping project of Saline County during the summer of 1946, and at that time many of the samples used in this investigation were collected. Mr. Brown used the same samples as the basis for a Master of Science thesis, and much valuable material was derived from this source.

LITERATURE

By definition, a soil catena is a group of soils within one zonal region developed from similar parent material but differing in characteristics of the solum owing to differences in relief or drainage. Jenny (5) rated climate as the outstanding factor which controls the soil forming processes. Vegetation is probably the next most important factor.

Byers, Kellogg, Anderson and Thorp (3) stated that over a long

period of time the effects of parent material on soil is obliterated. Many soils may be examined from the surface to a depth of two or three feet without finding any inkling as to the nature of the parent rock from which the soil material was derived. Heavy, waxy clays, whether calcareous or not, are very resistant to soil forming processes and may retain their essential parent material nature through long periods. Tvenhofel (10) observed that the minerals of soils are derived from parent rocks and to a greater or less extent are decomposition products formed from original minerals. Minerals derived from parent rocks are invariably present to some degree. Of them, quartz is by far the most abundant, and in many soils it is the dominant constituent. Other original minerals are some of the feldspars and micas, zircon, tourmaline, and other rarer minerals. The quantity and variety of minerals other than quartz depend upon the maturity of decomposition. If decomposition has advanced to maturity, the quantity and kind of original minerals are few.

Many of the inorganic substances of soils are of colloidal dimensions. These give hardness to the soils when dry and plasticity when wet. They absorb gases and organic and mineral substances and function in base exchange. Very frequently the colloidal matter is present as a coating on larger particles. It is said that colloidal matter makes up as much as 30 per cent of loams, 50 per cent of clay loams, and 75 per cent of clays.

Baldwin, Kellogg and Thorp (1) observed that similar parent material may be produced from different geologic deposits and in different ways, and unlike parent material may be produced from the same rocks because of differences in weathering.

The climate of Saline County and the surrounding area has been classified according to Thornthwaite (9) as sub-humid. Flora (4) lists the normal annual precipitation for the county as 27.00 inches. The normal annual mean temperature is 55.9 degrees Fahrenheit.

Moore, Frye and Jewett (8) have shown the main divisions of outcropping rock in Saline County to be Cretaceous and Permian. They have described the Wellington shale formation, the Ninnescah shale formation, the Kiowa shale formation and the Quaternary deposits. The detailed descriptions of the three shales are as follows:

> Wellington formation.--Chiefly shale, with a few hundred feet of salt in the middle part in the subsurface. Outcrops contain several more or less lenticular beds of gypsum and impure limestone. The Milan limestone member, consisting of 1 foot of greenish-gray shaly limestone that on the outcrop is characterized by bright-green copper carbonate, occurs at the top and thus marks the top of the Wellington formation in a comparatively large area. Elsewhere change in color from gray to red may be regarded as the upper boundary, which may be at different horizons in different places. The upper 300 feet of the Wellington is largely gray shale with thin interbedded deposits of calcareous material. The Hutchinson salt member occurs in the middle part but is not exposed. The fossil insect-bearing Herington limestone member occurs a short distance below the Hutchinson salt. Bright red and green shale is conspicuous in the lower part, which contains more or less discontinuous beds of impure limestone and gypsum. A bed of impure dolomitic limestone, not definitely known to be of widespread occurrence, has been named the Hollenberg limestone. In general, outcrops of the Wellington formation are poor and discontinuous. The total thickness of the formation is about . . . . . 700 feet
>
> Ninnescah shale.--Predominantly shale, mostly red, but containing some gray shale, impure limestone, and calcareous sandstone. The Hunnewell sandstone, 7 to 8 feet thick, forms the upper part of the formation. O. H. Norton has found that seven other distinctive beds of sandy or calcareous material can be traced for long distances. Some of the beds show ripple marks. Rosette-shaped calcareous concretions occur in the middle part. The average thickness at outcrop is about . . . . . 300 feet

Kiowa shale.--Shale, fissile, light gray, dark gray, and black, contains thin limestone beds throughout. Locally, lenticular sandstones occur at any position within the shale; selenite crystals common. Abundant marine molluscan fauna in the thin limestones, shale, and sandstone. Typical thickness, 60 to 150 foot; average . . . . . 102 feet

From the above it would be expected that catenas could be erected for each of the main divisions of outcropping rocks in Saline County. Brown (2) defined and proposed provisional names for three soil catenas in Saline County. These soil catenas and the soil series comprising each are as follows:

Wellington shale catena
- Kipp silt loam
- Idana silt loam
- Assaria silt loam
- Ladysmith silt loam

Ninnescah shale catena
- Vernon silty clay loam
- Cult silt loam
- Idana silt loam, reddish subsoil phase

Quaternary deposits catena
- Kiwo silt loam
- Berg silt loam
- Lockard silt loam

The series names are all tentative and must so remain until such time as the survey is completed and a final inspection and correlation is made. No catena was erected for the Kiowa shale since only one soil series developed from this parent material had been mapped.

The Kipp series consists of shallow to medium depth, friable calcareous soils which have developed from fine textured calcareous parent materials weathered from interbedded limestones and shales of Wellington age. They normally occur on moderately sloping convex ridge crests and slopes.

The Idana series consists of deep, mature, claypan soils which have developed from shales and limestones of Wellington age. They have weak-

brown, friable topsoils, dark-brown, hard, blocky clay subsoils, and moderate brown, friable parent materials. They normally occur on gently sloping convex portions of the upland, and have moderately rapid external drainage, and very slow internal drainage.

The Asseria soils consist of deep, dark colored claypan soils which have developed on moderately sloping upland areas from fine textured parent materials weathered from shales and limestones of Wellington age. They have dark, friable topsoils, dark, hard, blocky subsoils, and deep, moderately friable parent materials.

The Ladysmith series consists of dark, deep, mature claypan soils which have developed on nearly level to very gently sloping upland flats from fine textured parent materials weathered from shale and limestone of Wellington age. Ladysmith soils have dusky-brown to brownish-black topsoils, hard, blocky, dusky-brown subsoils, and deep friable, fine textured parent materials. They occur only on very flat or slightly depressed relief and have slow internal and external drainage.

The Vernon series consists of reddish-brown lithsols or shallow soils which have developed from fine textured calcareous reddish-brown and olive Hinnescah shale of Permian age.

The Galt series consists of medium depth, fine textured, reddish-brown soils which have developed on ridge crests and slopes from calcareous, fine textured, dark reddish-brown shale of Hinnescah age. They have brown surface soils, reddish-brown friable subsoils and dark reddish-brown calcareous parent materials.

The reddish subsoil phase of the Idana series has developed on red shales of Hinnescah age. These soils are associated with soils of the

Vernon and Galt series and are considered to be the mature member of the catena including these three soils. They occur on more gentle slopes than do the other two soils.

The Longford series consists of deep, mature claypan soils which have developed from fine textured parent materials weathered from the Kiowa shale of Cretaceous age. They have dark colored friable surface soils, dark to moderately dark colored, hard, blocky subsoils and deep, fine-textured parent materials. These soils do not have a true zone of accumulation, though lime concretions are usually present at about 40 inches.

The Kimo series consists of brown to reddish-brown, deep, friable, noncalcareous, silty soils, which have developed from deep, friable, loess-like parent materials of Quaternary age on undulating portions of the upland.

Soils of the Berg series consist of grayish-brown, deep, claypan soils which have developed on low, undulating hills in and bordering on old terraces and drainageways from fine textured brown to grayish-brown, loess-like materials of Quaternary age.

The Lockard series consists of weak brown claypan soils which have developed on old high terraces from moderate olive-brown plastic alluvial clays of Quaternary age. They have dark, friable, silty surface soils, weak brown, hard, blocky, clay subsoils and moderate olive-brown, alkaline, but non-calcareous parent materials.

EXPERIMENTAL METHODS

The soil samples provided by Mr. Brown of the Agronomy Department

of Kansas State College were collected by him during the summer of 1946. These samples and their locations are as follows:

54-1 Kipp silt loam. 150 feet east of the northwest corner of Sec. 18, T. 14 S., R. 1 W.

64-1 Idana silt loam. 1340 feet east of the northwest corner of Sec. 21, T. 16 S., R. 1 W.

64-2 Idana silt loam. 300 feet west of the southwest corner of Sec. 16, T. 16 S., R. 3 W.

84-2 Assaria silt loam. 500 feet south of the northwest corner of Sec. 36, T. 14 S., R. 1 W.

74-2 Ladysmith silt loam. 1000 feet south of the northeast corner of Sec. 36, T. 14 S., R. 1 W.

443-1 Vernon silty clay loam. 1340 feet south of the northwest corner of Sec. 29, T. 16 S., R. 4 W.

404-1 Galt silt loam. 1340 feet north of the southeast corner of Sec. 36, T. 16 S., R. 3 W.

64B-3 Idana silt loam, reddish subsoil phase. SW¼ Sec. 28, T. 16 S., R. 3 W.

35-3 Longford loam. 650 feet west of the northeast corner of Sec. 15, T. 13 S., R. 5 W.

464-1 Elno silt loam. SW¼ Sec. 11, T. 16 S., R. 3 W.

394-1 Berg silt loam. 500 feet east of the southwest corner of Sec. 33, T. 15 S., R. 3 W.

364-1 Lockard silt loam. 900 feet east of the northwest corner of Sec. 9, T. 16 S., R. 3 W.

Additional samples were collected later to provide information about the unweathered shales which were the supposed parent materials of some of the soils. The shale samples were collected from the same general area as the corresponding soil samples. The shale samples collected and the location of each is as follows:

1 Kiowa shale, near top of the formation. NE¼ NE¼ Sec. 15, T. 13 S., R. 5 W.

2 Wellington shale, lower portion. NW¼ NW¼ Sec. 21, T. 16 S., R. 3 W.

3 Winnescah shale, sampled in a road cut. SE¼ SW¼ Sec. 36, T. 16 S., R. 3 W.

4 Winnescah shale, below limestone parting, sampled in a streamcut bank. SW¼ SW¼ Sec. 29, T. 16 S., R. 1 W.

5 Winnescah shale, same location as number 4, but from above the limestone parting.

6 Wellington shale. NW¼ NW¼ Sec. 36, T. 14 S., R. 1 W.

7 Wellington shale. NW¼ NW¼ Sec. 19, T. 14 S., R. 1 W.

8 Winnescah shale, red, calcareous shale, slightly lower than sample 3. Sampled in a road cut. SE¼ NW¼ Sec. 36, T. 16 S., R. 3 W.

9 Winnescah shale, sand with thin clay partings. SE¼ SE¼ Sec. 21, T. 16 S., R. 2 W.

10 Winnescah shale, olive to drab, sampled in a road cut. SW¼ SW¼ Sec. 27, T. 16 S., R. 2 W.

11 Winnescah shale, about thirty feet lower than sample 10. Sampled in a road cut. NW¼ SW¼ Sec. 27, T. 16 S., R. 2 W.

12 Winnescah shale, sampled in a roadcut. SW¼ SW¼ Sec. 25, T. 16 S., R. 2 W.

13 Winnescah shale, sampled in a roadcut. SE¼ SW¼ Sec. 25, T. 16 S., R. 2 W.

14 Winnescah shale, about twenty feet below sample 13. Sampled in a stream cut bank. NW¼ NW¼ Sec. 36, T. 16 S., R. 2 W.

In collecting the soil samples, Mr. Brown dug pits, completely exposing the entire soil profile, and then each genetic horizon was sampled. Each soil profile sampled was located in an area of native grassland. Due to the poor exposures of Wellington shale in Saline County, the samples of Wellington shale were obtained by digging a pit through the soil profile into unweathered shale. In most cases it was impossible to determine the

relative stratigraphic position within the unit being sampled.

After collection each sample was air dried, crushed to pass a 2 mm sieve and stored. The field sample was carefully quartered until approximately 75 grams remained. This material was placed in a 16 ounce bottle preparatory to dispersing. Twenty cc of sodium silicate was added to serve as a deflocculent. The bottle was then filled completely with distilled water and shaken mechanically for 1½ hours. After shaking, each sample was allowed to stand for 15 minutes to allow the material of over five microns in diameter to settle out of suspension (Twenhofel, p. 198). The top 15 cm of the fluid was then decanted and evaporated to recover the clay fraction. No attempt was made to determine the quantity of clay in each sample. The clay fraction, after drying thoroughly, was ground to pass a 0.125 mm sieve, and then a differential thermal analysis of each clay was made. The particular differential thermal apparatus used has been described in detail in other papers and is very similar to those used in other laboratories. Briefly, the method consists of heating a small sample of the substance to be analyzed to approximately 1,000°C. at a rapid and constant rate of 33°C. per minute, and recording by suitable means the endothermic and exothermic effects. A differential thermocouple is used to detect these effects. One of the junctions is placed in the sample being studied, and the other is set in a thermally inert substance that is undergoing the same heat treatment as the sample. The temperatures at which these thermal effects take place and the intensities of the effects are characteristic for most minerals tested.

That portion of each sample remaining after the removal of the clay was then wet sieved on a 0.062 mm sieve with all of the material passing the

sieve being discarded. That portion of the sample retained on the sieve was then treated to clarify the sand grains. The clarification treatment consisted of boiling for ten minutes in hydrochloric acid, followed by ten minutes of boiling in 20 normal sodium hydroxide with the sample being washed until a neutral reaction was obtained after each period of boiling. The sample was air dried and sieved with the fraction passing the 0.125 mm sieve and retained on the 0.074 mm sieve being saved. This material was then separated into two parts on the basis of the specific gravity of the minerals. This separation was made by the use of bromoform (specific gravity about 2.7). The specific gravity of the bromoform was so controlled that a clear calcite cleavage fragment would float at all times.

Permanent microscope slides were made of each fraction by using Canada balsam (index of refraction about 1.54). Mineral counts were made of both the "heavy" and the "light" fractions of all samples. A mechanical stage was used to move the slide so that all of the grains on the slide could be counted without duplication. A 4 mm objective was used for the actual counting. After each slide was counted, a 16 mm objective was used to check each slide to make certain that no species of mineral was missed during the counting. The results of the mineral counts were computed as percentages of each mineral present in the sample and plotted as histograms.

Krumbein and Pettijohn (6) discuss the procedure used in separating mineral grains on a basis of specific gravity by the use of bromoform. The specific gravity of the bromoform may be controlled by the addition of alcohol to give a range of specific gravities from that of alcohol to

that of bromoform. The specific gravity of any particular mixture is best checked by the use of minerals of known specific gravity. Methods of recovering used bromoform are also discussed.

Milner (7) and Krumbein and Pettijohn (6) outline various methods for removing coatings on detrital mineral grains and also discuss the possible effects of such treatments on the minerals subjected to the treatment. Digestion in strong alkalies such as calcium or sodium hydroxide is recommended for the removal of opaline cements. Treatment with hydrochloric acid is suitable for the removal of iron and manganese oxide stains. It must be kept in mind during all such work that many changes may be effected upon the mineral grains by the treatment. All carbonate minerals will be removed by the acid treatment. Some of the ferro-magnesium minerals may have their optical properties affected, especially the refractive index and the 2 V of some minerals. To eliminate possible errors due to clarification treatment, the material should be examined before treating as well as after each stage of the process, and thus changes will be noted.

Krumbein and Pettijohn (6) discuss the accuracy of mineral counts of detrital grains and conclude that a minimum of three hundred grains should be counted for each sample to produce results which will be accurate within about five per cent. If fewer grains are counted, it is possible that some mineral present in small amounts may be missed entirely. The entire heavy mineral residue should be counted for study, and care must be exercised to make certain that the counting is representative. To aid in making the counting truly representative of the sample a mechanical stage should be used. It has been found that the

percentages of minerals present in a given material will vary from one size fraction to another size fraction and for this reason, the sample should be carefully sized, and the same size material should be used for all samples.

EXPERIMENTAL RESULTS

The mineral compositions of sample 4 and sample 5, two samples of the Winnescah shale collected at the same location but separated vertically by about 15 feet, are essentially identical. These two samples are very high in muscovite in the size range of 0.125 to 0.074 mm. Winnescah shale samples 3, 4, 5, 8, 9, 10, 11, 12, 13 and 14 are located on an east-west line in the southern part of Saline County. These samples show some variation in mineral compositions as they are traced to the eastward. Except for samples 4 and 5, the Winnescah shale contains less than 30 per cent muscovite in the 0.125 to 0.074 mm size.

The Wellington shale samples are very similar in mineral composition. All of the samples have a very high content of muscovite, ranging from 55 per cent to 90 per cent in the size range 0.125 to 0.074 mm.

The Kiowa shale also has a very high percentage of muscovite, but has a considerably higher percentage of hornblende than the Wellington shale in the 0.125 to 0.074 mm size fraction.

Samples 35-3-B and 35-3-C are soil samples from Sec. 15, T. 13 S., R. 5 W., and sample 1 is a sample of the Kiowa shale from the same location. Sample 35-3-C is very similar in mineral composition to sample 1. In sample 35-3-B the amount of muscovite has been sharply reduced with a

EXPLANATION OF PLATE I

Fig. 1. Mineral composition of the Wellington shale, sample 2.

Fig. 2. Mineral composition of the Wellington shale, sample 6.

Fig. 3. Mineral composition of the Wellington shale, sample 7.

PLATE I

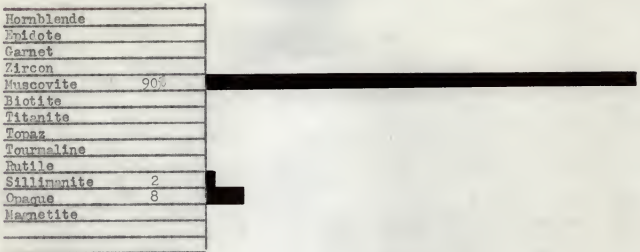


Fig. 1.

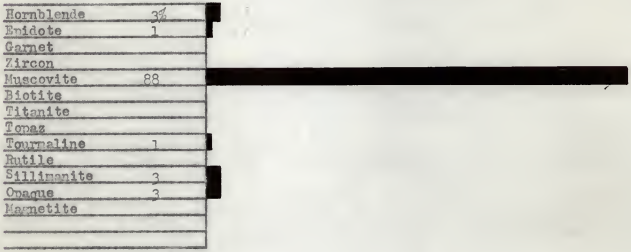


Fig. 2.

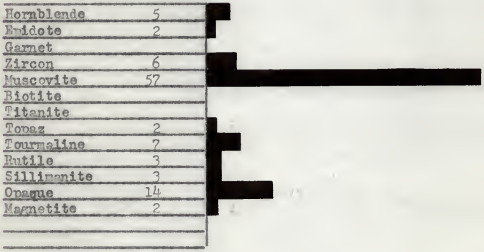


Fig. 3.

EXPLANATION OF PLATE II

Fig. 1. Mineral composition of the B horizon of the Kipp silt loam, sample 54-1-B.

Fig. 2. Mineral composition of the C horizon of the Kipp silt loam, sample 54-1-C.

Fig. 3. Mineral composition of the D horizon of the Kipp silt loam, sample 54-1-D.

PLATE II

Hornblende	14%
Epidote	6
Garnet	3
Zircon	11
Muscovite	26
Biotite	
Titanite	
Topaz	
Tourmaline	9
Rutile	4
Sillimanite	1
Opaque	20
Magnetite	7

Fig. 1.

Hornblende	5%
Epidote	5
Garnet	
Zircon	5
Muscovite	34
Biotite	4
Titanite	1
Topaz	
Tourmaline	2
Rutile	3
Sillimanite	
Opaque	31
Magnetite	5
Kyanite	4

Fig. 2.

Hornblende	15%
Epidote	3
Garnet	3
Zircon	8
Muscovite	28
Biotite	2
Titanite	1
Topaz	1
Tourmaline	10
Rutile	2
Sillimanite	
Opaque	19
Magnetite	6

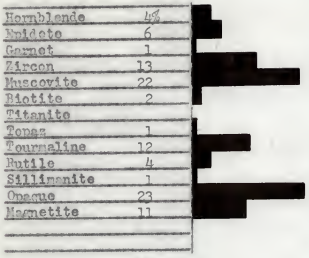
Fig. 3.

EXPLANATION OF PLATE III

Fig. 1. Mineral composition of the B horizon of the Idana silt loam, sample 64-1-B.

Fig. 2. Mineral composition of the C horizon of the Idana silt loam, sample 64-1-C.

PLATE III



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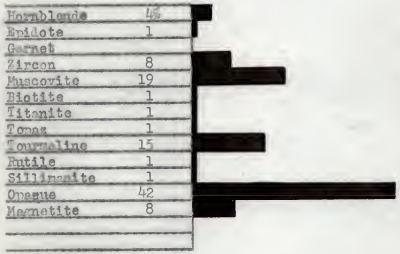


Fig. 2.

EXPLANATION OF PLATE IV

Fig. 1. Mineral composition of the B horizon of the Idona silt loam, sample 64-2-B.

Fig. 2. Mineral composition of the C horizon of the Idona silt loam, sample 64-2-C.

PLATE IV

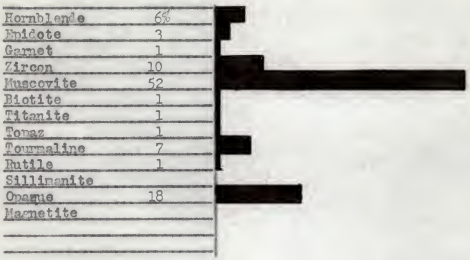


Fig. 1.

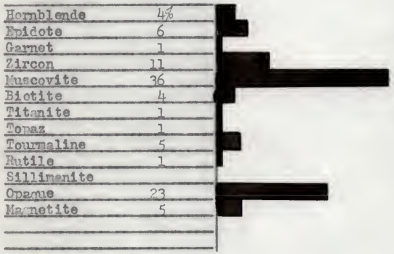


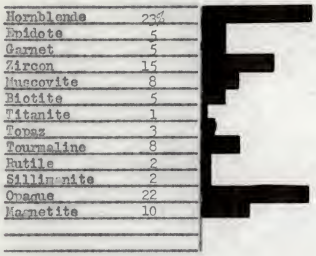
Fig. 2.

EXPLANATION OF PLATE V

Fig. 1. Mineral composition of the B horizon of the Assaria silt loam, sample 84-2-B.

Fig. 2. Mineral composition of the C horizon of the Assaria silt loam, sample 84-2-C.

PLATE V



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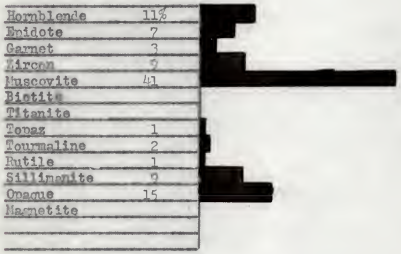


Fig. 2.

EXPLANATION OF PLATE VI

Fig. 1. Mineral composition of the B horizon of the Ladysmith silt loam, sample 7¼-2-B.

Fig. 2. Mineral composition of the C horizon of the Ladysmith silt loam, sample 7¼-2-C.

PLATE VI

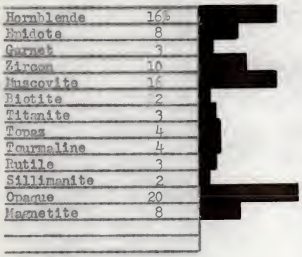


Fig. 1.

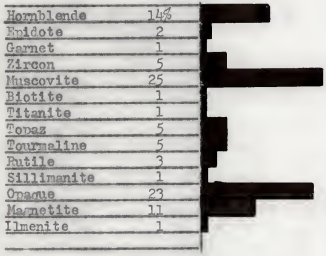


Fig. 2.

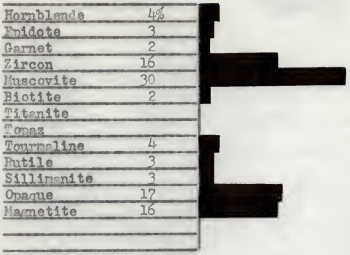
EXPLANATION OF PLATE VII

Fig. 1. Mineral composition of the Minnecoah chalk, sample 3.

Fig. 2. Mineral composition of the Minnecoah chalk, sample 4.

Fig. 3. Mineral composition of the Minnecoah chalk, sample 5.

PLATE VII



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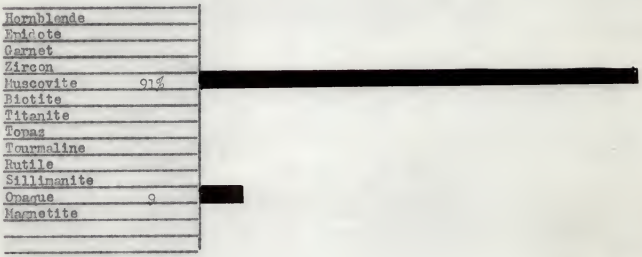


Fig. 2.

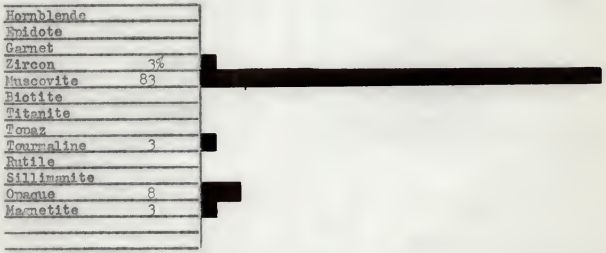


Fig. 3.

EXPLANATION OF PLATE VIII

Fig. 1. Mineral composition of the Winnescah shale, sample 8.

Fig. 2. Mineral composition of the Winnescah shale, sample 9.

Fig. 3. Mineral composition of the Winnescah shale, sample 10.

PLATE VIII

Hornblende	12%
Epidote	
Garnet	
Zircon	15
Muscovite	29
Biotite	
Titanite	
Topaz	5
Tourmaline	3
Rutile	3
Sillimanite	
Opaque	23
Magnetite	9
Pyrite	1

Fig. 1.

Hornblende	8%
Epidote	5
Garnet	
Zircon	15
Muscovite	20
Biotite	2
Titanite	
Topaz	6
Tourmaline	6
Rutile	2
Sillimanite	
Opaque	24
Magnetite	12

Fig. 2.

Hornblende	9%
Epidote	4
Garnet	
Zircon	14
Muscovite	14
Biotite	
Titanite	
Topaz	3
Tourmaline	9
Rutile	4
Sillimanite	
Opaque	27
Magnetite	16

Fig. 3.

EXPLANATION OF PLATE IX

Fig. 1. Mineral composition of the Winnecash shale, sample 11.

Fig. 2. Mineral composition of the Winnecash shale, sample 12.

PLATE IX

Hornblende	13%
Epidote	4
Garnet	1
Zircon	16
Muscovite	15
Biotite	2
Titanite	
Topaz	6
Tourmaline	12
Rutile	4
Sillimanite	
Opaque	16
Magnetite	11

Fig. 1.

Hornblende	7%
Epidote	3
Garnet	
Zircon	17
Muscovite	13
Biotite	
Titanite	
Topaz	7
Tourmaline	3
Rutile	4
Sillimanite	
Opaque	22
Magnetite	11
Celestite	13

Fig. 2.

EXPLANATION OF PLATE X

Fig. 1. Mineral composition of the Minnesoah shale, sample 13.

Fig. 2. Mineral composition of the Minnesoah shale, sample 14.

PLATE X

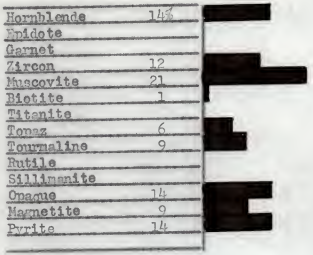


Fig. 1.

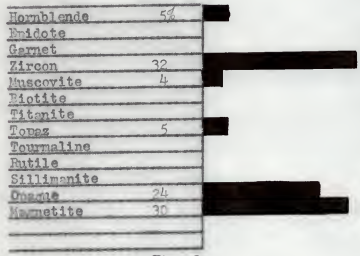


Fig. 2.

EXPLANATION OF PLATE XI

Fig. 1. Mineral composition of the B horizon of the Vernon silty clay loam, sample 443-1-B.

Fig. 2. Mineral composition of the C horizon of the Vernon silty clay loam, sample 443-1-C.

Fig. 3. Mineral composition of the D horizon of the Vernon silty clay loam, sample 443-1-D.

PLATE XI

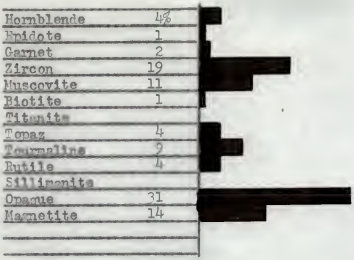


Fig. 1.

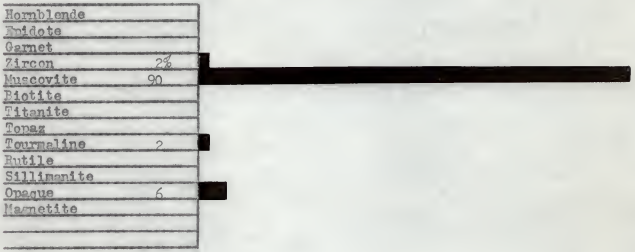


Fig. 2.

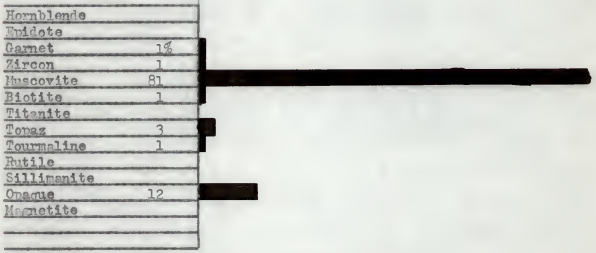


Fig. 3.

EXPLANATION OF PLATE XII

Fig. 1. Mineral composition of the B horizon of the Galt silt loam, sample 40A-1-B.

Fig. 2. Mineral composition of the C horizon of the Galt silt loam, sample 40A-1-C.

Fig. 3. Mineral composition of the D horizon of the Galt silt loam, sample 40A-1-D.

PLATE XII

Hornblende	5%
Epidote	4
Garnet	
Zircon	9
Muscovite	24
Biotite	
Titanite	
Topaz	3
Tourmaline	11
Rutile	3
Sillimanite	
Opaque	29
Magnetite	11

Fig. 1.

Hornblende	6%
Epidote	2
Garnet	1
Zircon	14
Muscovite	20
Biotite	1
Titanite	
Topaz	3
Tourmaline	6
Rutile	4
Sillimanite	
Opaque	28
Magnetite	14

Fig. 2.

Hornblende	5%
Epidote	1
Garnet	1
Zircon	17
Muscovite	19
Biotite	1
Titanite	
Topaz	2
Tourmaline	11
Rutile	3
Sillimanite	
Opaque	27
Magnetite	13

Fig. 3.

EXPLANATION OF PLATE XIII

Fig. 1. Mineral composition of the B horizon of the Idona silt loam, reddish subsoil phase, sample 6/B-3-B.

Fig. 2. Mineral composition of the C horizon of the Idona silt loam, reddish subsoil phase, sample 6/B-3-C.

PLATE XIII

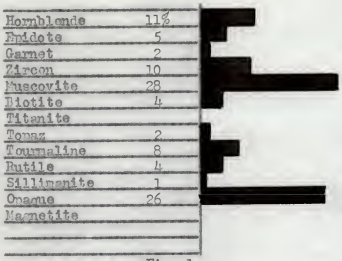


Fig. 1.

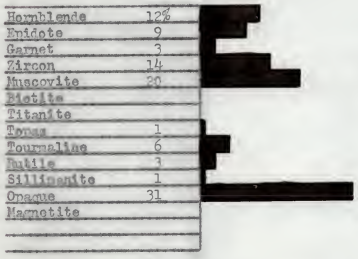


Fig. 2.

EXPLANATION OF PLATE XIV

Fig. 1. Mineral composition of the B horizon of the Longford loam, sample 35-3-B.

Fig. 2. Mineral composition of the C horizon of the Longford loam, sample 35-3-C.

Fig. 3. Mineral composition of the Kiowa shale, sample 1.

PLATE XIV

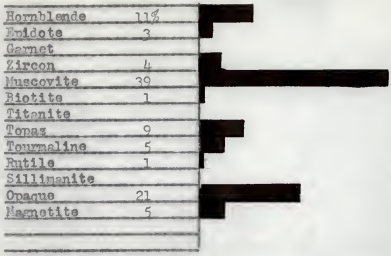


Fig. 1.

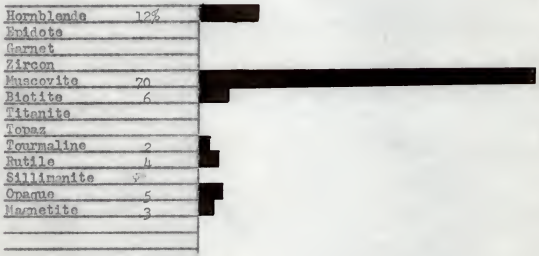


Fig. 2.

Fig. 3.

EXPLANATION OF PLATE XV

Fig. 1. Mineral composition of the B horizon of the Pine silt loam, sample 464-1-B.

Fig. 2. Mineral composition of the C horizon of the Pine silt loam, sample 464-1-C.

PLATE XV

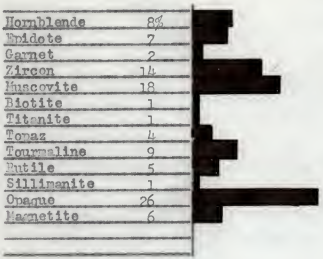


Fig. 1.

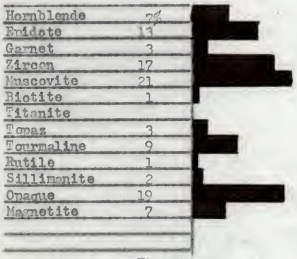


Fig. 2.

EXPLANATION OF PLATE XVI

Fig. 1. Mineral composition of the B horizon of the Berg silt loam, sample 394-1-B.

Fig. 2. Mineral composition of the C horizon of the Berg silt loam, sample 394-1-C.

PLATE XVI

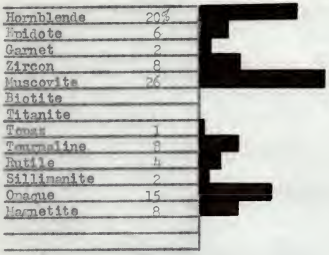


Fig. 1.

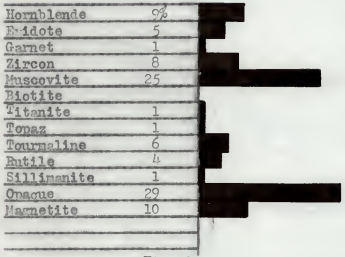


Fig. 2.

EXPLANATION OF PLATE XVII

Fig. 1. Mineral composition of the B horizon of the Lockard silt loam, sample 364-1-B.

Fig. 2. Mineral composition of the C horizon of the Lockard silt loam, sample 364-1-C.

PLATE XVII

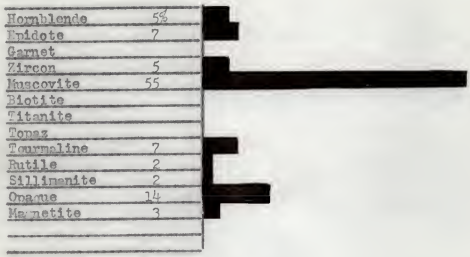


Fig. 1.

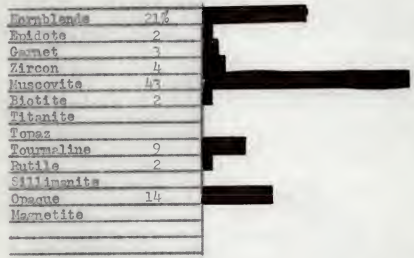


Fig. 2.

corresponding increase in the percentages of the ferro-magnesium minerals.

The mineral compositions of sample 443-1-C and sample 443-1-D are very much alike. Also, these two soil samples are very similar to the Minnescah shale samples from the same location. The two soil samples each have over 80 per cent muscovite in the 0.125 to 0.074 mm size. In the B zone of the soil the muscovite content has been reduced to 11 per cent.

Samples 6MR-3 and 404-1 are soils supposedly developed from the Minnescah shale. The B horizons and the C horizons of these two soils are similar in mineral composition. The mineral composition of the D zone of sample 404-1 is very much like the mineral composition of the samples 3 and 8. The percentage of muscovite in the 0.125 mm to 0.074 mm range in the B horizon of both of these soils is much lower than in the C horizon.

Sample 6 has a very high muscovite concentration in the size fraction of 0.125 to 0.074 mm. In the C horizon of the soils developed in the vicinity of this sample there has been considerable reduction in the amount of muscovite. Samples 8A-2-B and 7A-2-B, soils developed on the Wellington shale, are very similar in mineral composition. All of the other soils developed from the Wellington shale show the same general mineral compositions and relation to parent materials as do 8A-2 and 7A-2.

The mineral compositions of the two soils developed from loess-like material are similar, and both soils show little change in composition between the B horizon and the C horizon.

Sample 364-1, a soil developed from alluvial clay, has a rather high content of muscovite in the 0.125 to 0.074 mm size fraction in both the B and the C horizons. There is little change mineralogically from the B to the C horizons.

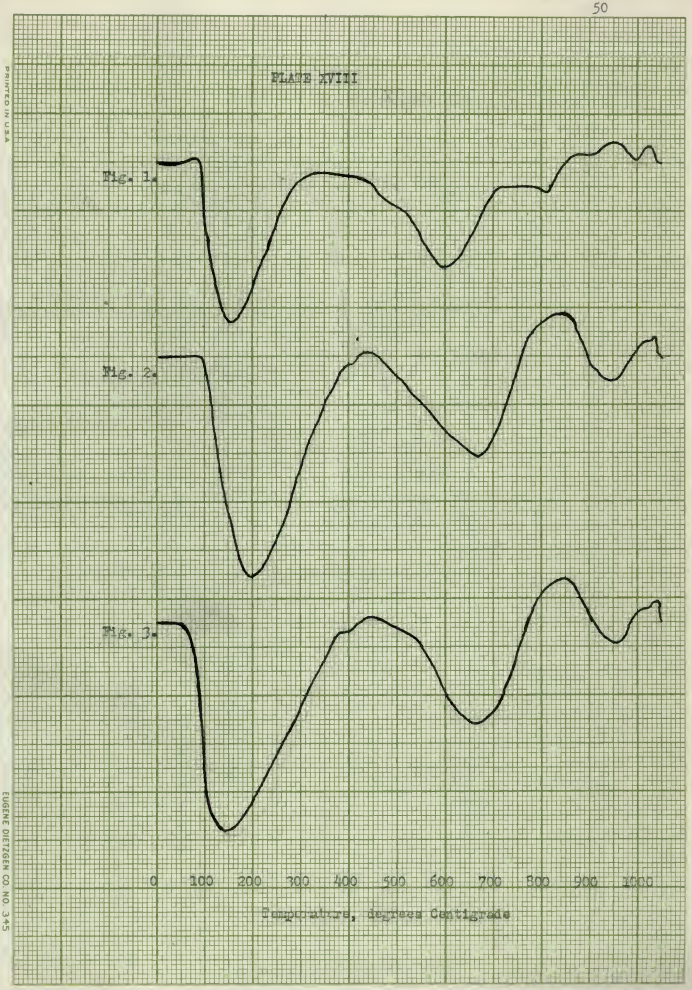
EXPLANATION OF PLATE XVIII

Fig. 1. Differential thermal analysis of the clay fraction of sample 54-1-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 54-1-C.

Fig. 3. Differential thermal analysis of the clay fraction of sample 54-1-D.

PLATE XVIII



EXPLANATION OF PLATE XIX

Fig. 1. Differential thermal analysis of the clay fraction of sample 64-1-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 64-1-C.

Fig. 3. Differential thermal analysis of the clay fraction of sample 64-2-B.

Fig. 4. Differential thermal analysis of the clay fraction of sample 64-2-C.

PLATE XIX

EXPLANATION OF PLATE XX

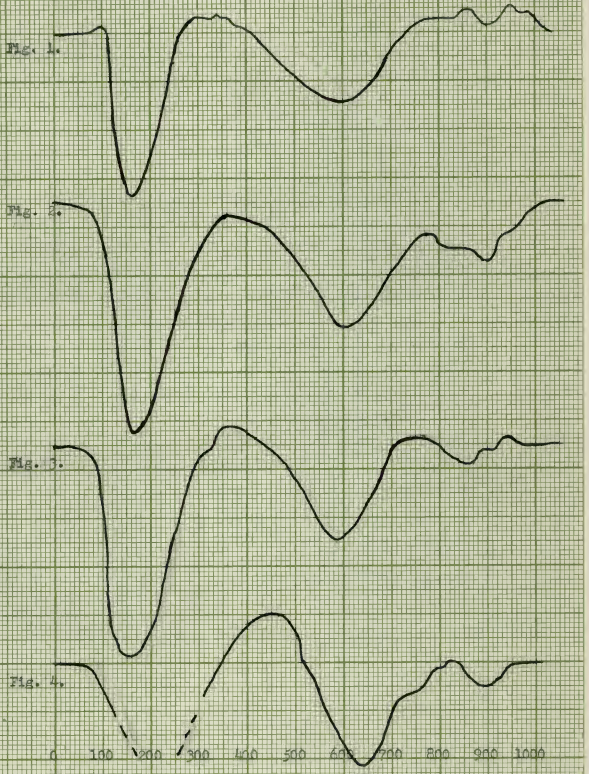
Fig. 1. Differential thermal analysis of the clay fraction of sample 8½-2-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 8½-2-C.

Fig. 3. Differential thermal analysis of the clay fraction of sample 7½-2-B.

Fig. 4. Differential thermal analysis of the clay fraction of sample 7½-2-C.

PLATE XX



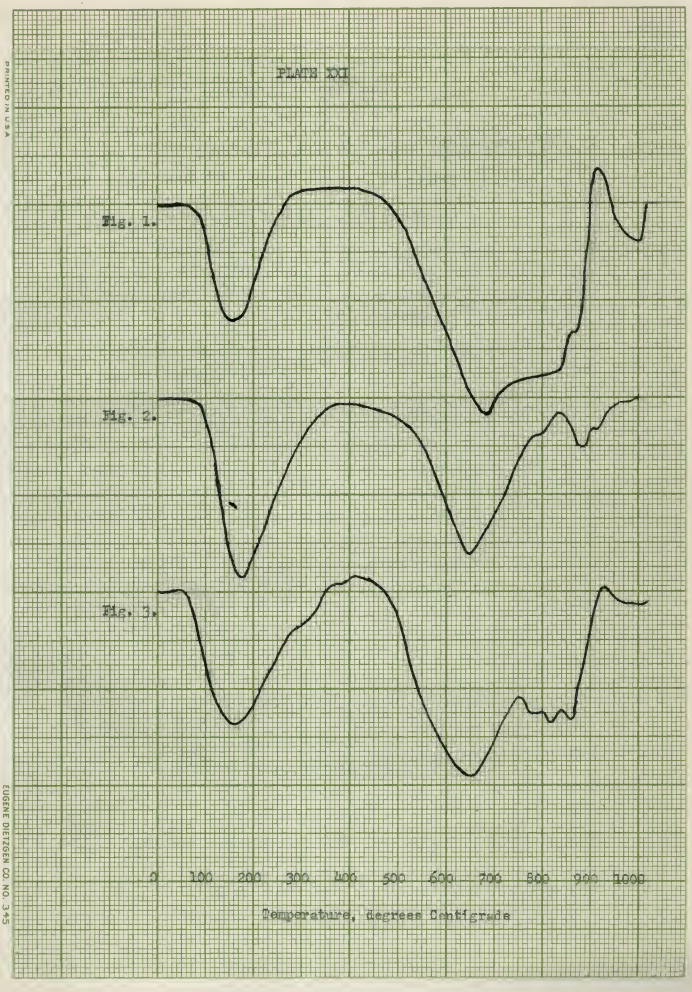
EXPLANATION OF PLATE XXI

Fig. 1. Differential thermal analysis of the clay fraction of sample 2.

Fig. 2. Differential thermal analysis of the clay fraction of sample 6.

Fig. 3. Differential thermal analysis of the clay fraction of sample 7.

PLATE XXI



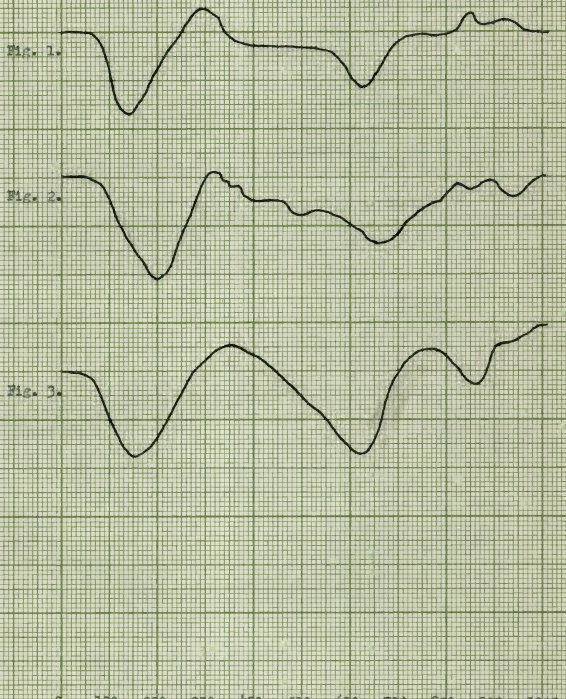
EXPLANATION OF PLATE XXII

Fig. 1. Differential thermal analysis of the clay fraction of sample 443-1-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 443-1-C.

Fig. 3. Differential thermal analysis of the clay fraction of sample 443-1-D.

PLATE XXXI



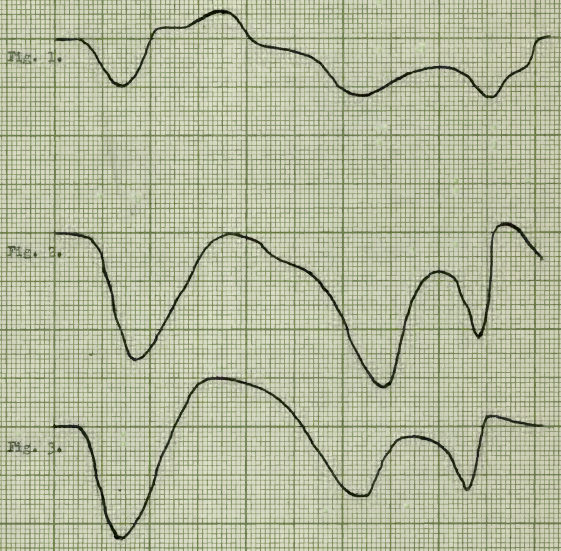
EXPLANATION OF PLATE XXIII

Fig. 1. Differential thermal analysis of the clay fraction of sample 404-1-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 404-1-C.

Fig. 3. Differential thermal analysis of the clay fraction of sample 404-1-D.

PLATE XXIII



EXPLANATION OF PLATE XXIV

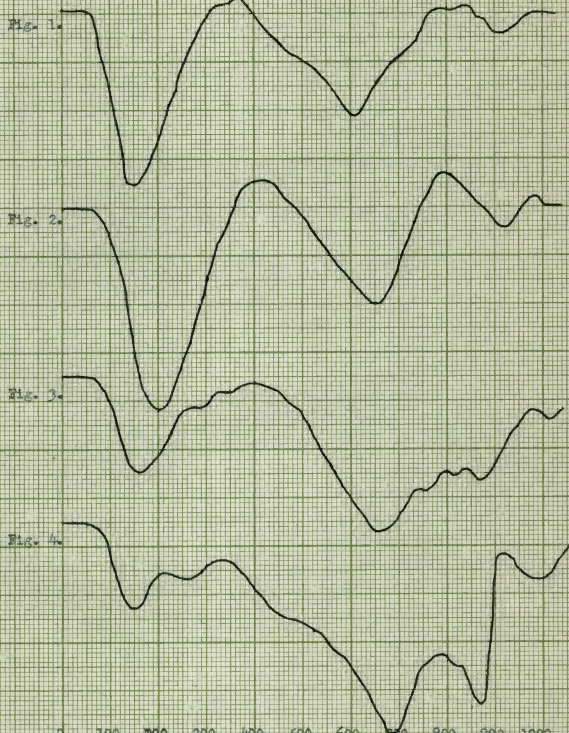
Fig. 1. Differential thermal analysis of the clay fraction of sample 6[illegible]-3-1.

Fig. 2. Differential thermal analysis of the clay fraction of sample 6[illegible]-3-0.

Fig. 3. Differential thermal analysis of the clay fraction of sample 3.

Fig. 4. Differential thermal analysis of the clay fraction of sample 4.

PLATE XXIV



EXPLANATION OF PLATE XXV

Fig. 1. Differential thermal analysis of the clay fraction of sample 5.

Fig. 2. Differential thermal analysis of the clay fraction of sample 8.

Fig. 3. Differential thermal analysis of the clay fraction of sample 9.

Fig. 4. Differential thermal analysis of the clay fraction of sample 10.

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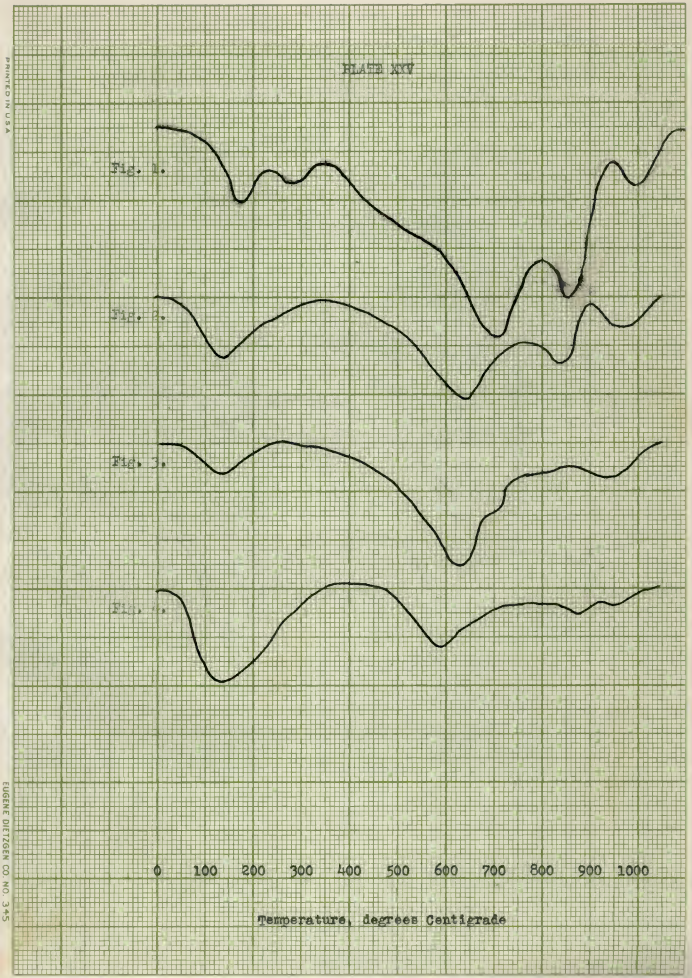
PLATE XXV



EXPLANATION OF PLATE XXVI

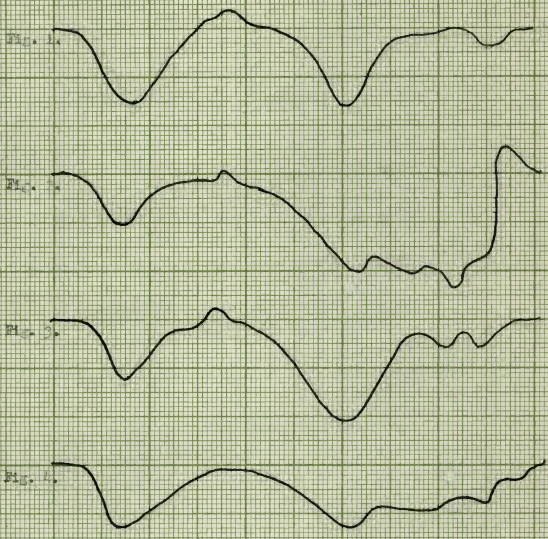
Fig. 1. Differential thermal analysis of the clay fraction of sample 11.

Fig. 2. Differential thermal analysis of the clay fraction of sample 12.

Fig. 3. Differential thermal analysis of the clay fraction of sample 13.

Fig. 4. Differential thermal analysis of the clay fraction of sample 14.

PLATE XXVI



EXPLANATION OF PLATE XXVII

Fig. 1. Differential thermal analysis of the clay fraction of sample 35-3-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 35-3-C.

Fig. 3. Differential thermal analysis of the clay fraction of sample 1.

PLATE XXVII

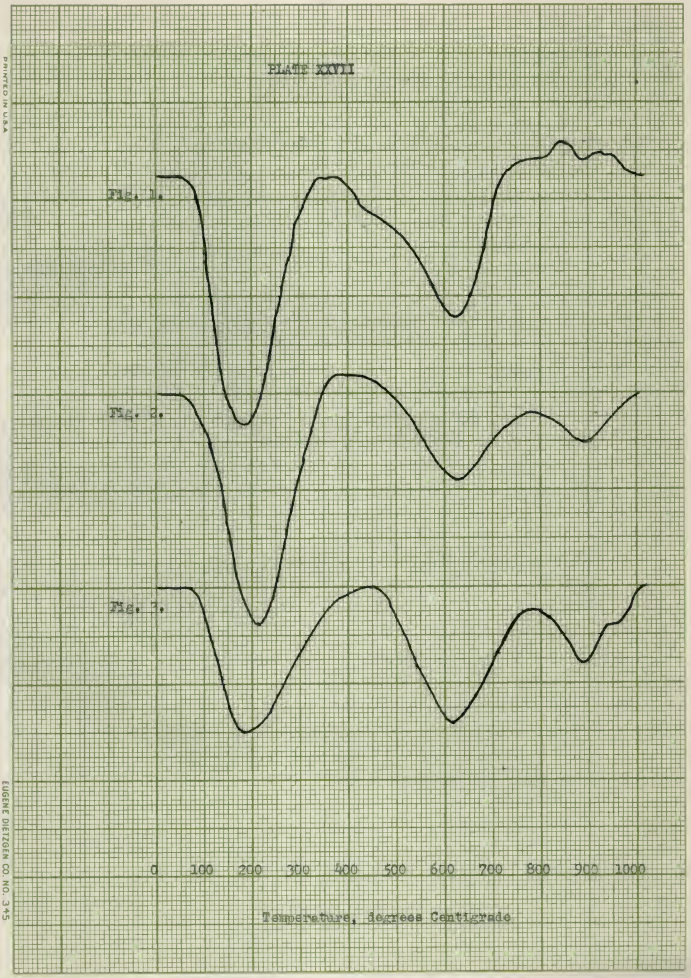


PLATE XXVIII

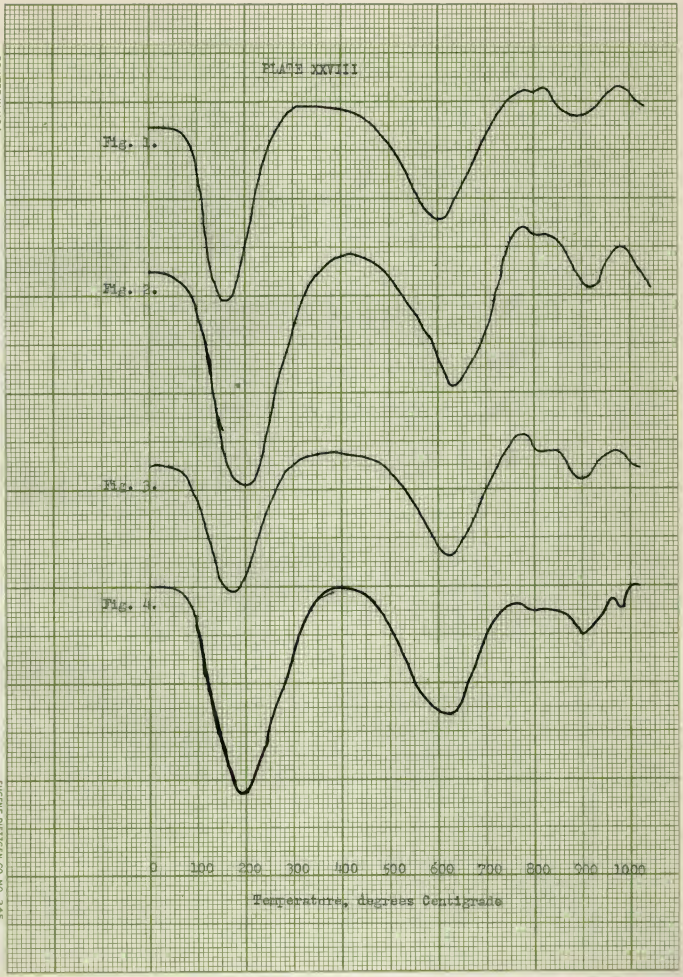
Fig. 1. Differential thermal analysis of the clay fraction of sample 464-1-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 464-1-C.

Fig. 3. Differential thermal analysis of the clay fraction of sample 394-1-B.

Fig. 4. Differential thermal analysis of the clay fraction of sample 394-1-C.

PLATE XXVIII



EXPLANATION OF PLATE XXIX

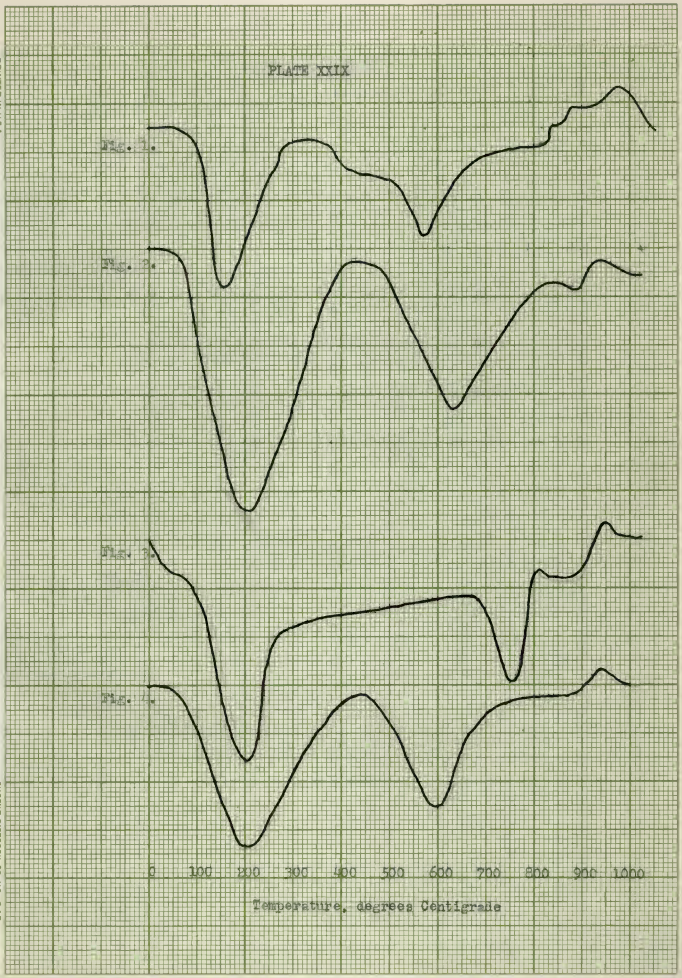
Fig. 1. Differential thermal analysis of the clay fraction of sample 364-1-B.

Fig. 2. Differential thermal analysis of the clay fraction of sample 364-1-C.

Fig. 3. Differential thermal analysis of the clay, Montmorillonite, standard sample.

Fig. 4. Differential thermal analysis of the clay, Illite, standard sample.

PLATE XXIX



CONCLUSIONS

In many cases it would be possible to distinguish the Winnesoah shale from the Wellington shale or the Nicva shale on the basis of the percentage of muscovite present in the 0.125 to 0.074 mm fraction. In most of the Winnesoah shale samples, the percentage of muscovite in the size range from 0.125 to 0.074 mm is between 20 and 30 per cent, while in the Wellington shale and the Nicva shale the percentage of muscovite of the same size is over 50 percent.

The variation noted in the Winnesoah shale samples is probably a reflection of the position of the sample within the stratigraphic unit. According to Moore, Frye, and Jewett (8, p. 143) the general dip of Paleozoic strata in Kansas is from 15 to 35 feet to the mile west or northwest. Therefore, successively younger formations of rocks would be encountered to the eastward at the surface of the North. Samples 3 and 8, located in the south central part of Saline County are probably close to the top of the Winnesoah shale and samples 4 and 5, located in the southeast part of Saline County are undoubtedly near the base of the formation, with samples 9 through 14 in intermediate positions within the formation.

From his investigation of the soils of Saline County, Brown (2) concluded that the Colt silt loam, sample 404-1, should not be included as a member of the Winnesoah shale catena. Comparison of the mineral compositions of samples 3 and 8, Winnesoah shale samples, and samples 647-3 and 404-1 show that the soils in both cases are very much alike and that both soils reflect the mineral composition of the

parent material.

A study of the C and D horizons of all of the soils developed from the Minnesoah shale shows that the soils are residual. Differences in the C horizons of the various soils are due to variations within the Minnesoah shale itself.

The mineral composition of sample 35-3-C, the C horizon of a soil developed on the Kiowa shale, is nearly the same as the mineral composition of the unweathered Kiowa shale at the same location. This similarity can be interpreted to mean that the soil is residual. The sharp reduction in the percentage of muscovite is probably the result of the more complete decomposition of the D horizon. The increase in the percentages of other minerals does not indicate an actual increase in quantity, but merely a change in relative abundance of the component minerals. As decomposition progresses, the variety and the quantities of minerals other than quartz (or chalcedony) and clay should decrease.

The mineral compositions of the samples of Wellington shale indicate that the Wellington shale is fairly uniform in composition over a wide area. The percentage of muscovite in the 0.125 to 0.074 mm size range in the Wellington shale is so high that many of the other minerals which could be present may be masked. The mineral compositions of the various soils developed from the Wellington shale are very much alike and are also similar to the composition of the Wellington shale. These soils are evidently residual soils.

There is considerable difference in the mineralogy of the soils developed on loess-like materials and the soil developed on the alluvial clay material. The principal difference in these two soils is the very

high muscovite content of the alluvial soil in the 0.125 to 0.074 mm size range. There is also a marked difference in the percentage of hornblende in that range, with the alluvial soil having at least two times as much hornblende as the loess-like soils. The B horizon of the soils developed on the Wellington shale are rather high in hornblende percentages, and possibly the hornblende of the alluvial soil was derived from the weathered Wellington shale.

In all of the soils studied it was possible to trace the minerals of the parent material through all of the soil horizons. Some of the minerals were examined for special structures or features which could be utilized to more definitely identify the mineral grains and as possible clues to origin of the minerals. Such features as crystal outline, inclusions, degree of rounding, etc., were used. Few positive results were obtained, however. Nearly all of the grains of tourmaline observed displayed good crystal outline and showed no evidence of zonal growth. A few grains were noted which had unusual pleochroism, but their distribution was apparently haphazard. The hornblende grains were invariably somewhat rounded.

The zircon of the loess-like soils were fairly well rounded, but in all of the other samples, when present, was in well developed crystals. Some differences in the color of the zircons of the Minnesoah shale and the Wellington shale were noted. The zircon of the Minnesoah shale commonly has a pinkish color, but this is often lost in the zircon of the B horizon of the soil developed from the Minnesoah shale. This color difference may be characteristic and would indicate some change in the source of sediments for the Minnesoah shale from that of the Wellington shale.

The differential thermal analysis data indicate that the clay mineral present in most of the soils and shales examined is an illite. Illite is a potassium-bearing clay mineral. Mixed with the clay fraction in some of the samples are varying quantities of other minerals. By comparing the curve of the unknown material with curves produced by known samples it is possible in many cases to identify the components of the unknown.

The small "peaks" found in some of the tests near the upper temperature range probably indicate the presence of calcite in the sample.

Comparison of the clay mineral of the various horizons within each soil series shows that the type of clay is remarkably persistent throughout the soil profile. There are some differences in the graphs, but these changes consist principally of variations of the temperature at which the peaks are produced and do not indicate any important change in the clay mineral. The clay of the B horizons of most of the soils produced peaks at lower temperatures than the corresponding peaks in the clay of the C horizon of the same soil.

The type of clay mineral in the soils produced from alluvial material is very similar to the type of clay mineral in the shales of the area. This fact tends to confirm the assumption that the Wallington shale is the source of the alluvial material.

The type of clay produced is probably the result of the type and extent of decomposition effective on the various parent materials and does not indicate any differences in the parent materials.

Comparison of the B horizons of all of the soils show that the soils tend to develop similar mineral compositions. In nearly all cases the percentage of muscovite in the size range 0.125 to 0.074 mm in the B

horizon is much less than that of the C horizon of the same soil. This would indicate that the muscovite weathers quite rapidly, probably producing a clay mineral.

There is considerable variation in the compositions of the C horizons of the various soils. These differences reflect the differences found in the parent materials of the soils. Apparently the effect of the parent material on the mature soil is very slight.

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LITERATURE CITED

1 Baldwin, Mark, Charles E. Kellogg, and James Thorp. Soil Classification. Yearbook of Agriculture, 1938 (Soils and Men). United States Department of Agriculture. Washington: Government Printing Office, 1938.

2 Brown, Paul L. Some Catena Relationships in the Soils of Saline County, Kansas. Unpublished M. S. Thesis, Kansas State College, Manhattan, Kansas, 1948.

3 Byers, H. G., Charles E. Kellogg, M. S. Anderson, and James Thorp. Formation of Soil. Yearbook of Agriculture, 1938 (Soils and Men). United States Department of Agriculture. Washington: Government Printing Office, 1938.

4 Flora, Snowden D. Climate of Kansas. Report of the Kansas State Board of Agriculture 67: No. 265. 239 p. 1948.

5 Jenny, H. Calcium in the Soil: III Pedologic Relations. Soil Sci. Soc. Amer. Proc. 6:36-35. 1941.

6 Krumbein, W. C., and F. J. Pettijohn. Manual of Sedimentary Petrography. New York-London: Appleton-Century-Crofts, 1938.

7 Milner, Henry B. Sedimentary Petrography. Second Edition. London: Thomas Murby, 1929.

8 Moore, Raymond C., John C. Frye, and John Mark Jewett. Tabular Description of Outcropping Rocks in Kansas. University of Kansas Publications: State Geological Survey of Kansas. Bul. 53, Part 4: 141-212. 1944.

9 Thornthwaite, C. W. The Climates of North America According to a New Classification. Geog. Rev. 21: 633-654. 1931.

10 Twenhofel, W. H. Principles of Sedimentation. New York-London: McGraw-Hill, 1939.